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(54) Printhead and a method for the manufacture thereof.

(57) An inkjet printhead including a flexible substrate (10) having at least one fold (11) therein such that a first section (12) of the substrate overlies a second section (13) of the substrate. Inkdrop ejection chambers (14) are disposed between opposed surfaces of the first and second sections of the substrate. Ink inlet orifices (17) are provided in the first section of the substrate and each of the ink inlet orifices is in fluid communication with a respective one of the inkdrop ejection chambers. Ink outlet apertures (18) are provided in the second section of the substrate and each of the ink outlet apertures is in fluid flow communication with a respective one of the inkdrop ejection chambers.

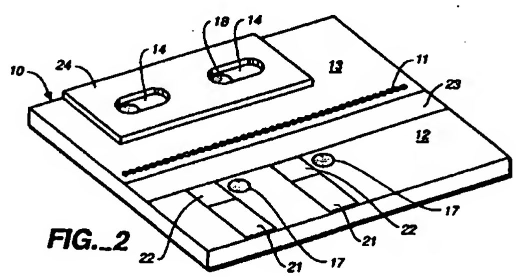

FIG._2

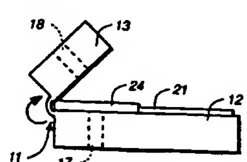

FIG._3

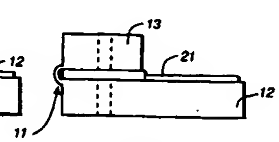

FIG._4

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The present invention generally relates to printheads for inkjet printers.

Figure 1 shows an example of a conventional printhead for a thermal inkjet printer. The printhead includes a substrate 1, an intermediate layer 2, and an orifice plate 3. A nozzle 4 is formed in the orifice plate, and a vaporization cavity 5 is defined between the substrate and the orifice plate. For convenience of illustration, the drawing shows only one of the nozzles in the orifice plate; however, a complete inkjet printhead includes an array of circular nozzles, each of which is paired with a vaporization cavity. Moreover, a complete inkjet printhead includes channels that connect vaporization cavities to an ink supply.

Furthermore, in a complete printhead, each vaporization cavity includes a heater resistor such as the resistor 6 in figure 1. In practice, the heater resistors on a printhead are connected in an electrical network for selective activation. When a particular heater resistor receives a pulse, the electrical energy is rapidly converted to heat which then causes ink adjacent to the heater resistor to form a vapor bubble 7. As the vapor bubble expands due to the heat provided by an energized heater resistor, the bubble ejects a droplet of ink from the nozzle in the orifice plate. This action is schematically illustrated in Figure 1 with the direction of bubble growth being indicated by the arrow. By appropriate selection of the sequence of energizing the heater resistors, the ejected ink droplets can form patterns such as alphanumeric characters.

In practice, the quality of print provided by inkjet printers depends upon the physical characteristics and relative positioning of the ink ejection nozzles, resistors, vaporization cavities and ink inlet channels. More particularly, the design of these elements in a printhead determine the size, trajectory, frequency response and speed of ink drop ejection. In some instances, geometry can affect the ejection of ink from adjacent nozzles crosstalk.

There are several shortcomings to conventional processes for fabricating inkjet printheads. One shortcoming is that an accurate positioning step is required as the nozzle plate is assembled together with the substrate. This positioning step is costly because of the time and expensive equipment required. A further shortcoming of conventional processes occurs during the temperature cycling which a printhead experiences during use. This cycling sets up stresses and strains in the assembly since the nozzle plate and substrate have differing coefficients of thermal expansion. These stresses and strains can cause delamination of the part under extreme cases.

Generally speaking, the present invention provides a printhead that includes a flexible substrate having at least one fold therein such that a first section of the substrate can be folded to overlie a second section of the substrate. A printhead according to the present invention combines the advantages of printheads comprising flexible, extendible substrates wherein the resistors and orifices are provided on the same section of a substrate with the efficiency and layout advantages of printheads wherein the resistor substrate and orifice plate are separate parts. That is, more space is available to lay out resistors and conductors and the arrangement has higher drop ejection efficiency than the arrangement wherein the resistors and orifices are provided on the same section of a substrate.

In a preferred embodiment of the present invention, a plurality of drop ejection chambers are disposed between opposed surfaces of the first and second sections of the substrate, a plurality of ink inlet orifices are provided in the first section of the substrate and each of the ink inlet orifices are in fluid communication with a respective one of the drop ejection chambers. A plurality of ink outlet apertures can be provided in the second section of the substrate with each of the ink outlet apertures in fluid communication with a respective one of the drop ejection chambers and a bulk ink supply can be provided in direct fluid communication with each of the ink inlet orifices. The flexible substrate can also include at least two folds therein such that a third section of the substrate overlies at least one of the first and second sections.

The fold means can comprise a row of spaced-apart perforations in the substrate, a slot or slots extending only part way through the substrate, or a weakened portion of the substrate which allows the substrate to be folded such that the first section of the substrate on one side of the weakened portion overlies the second section on an opposite side of the weakened portion. As the part is folded or sometime thereafter, the sections are permanently adhered to each other to form a single structure. The means employed to adhere the parts can make use of heat, pressure, UV light or other means to cure a glue layer before folding. Alternatively with the proper choice of materials and curing means either the substrate or barrier material may also be utilized as the adhesive.

In a preferred printhead the inkdrop ejection chamber comprises a photo-ablated region extending at least part way and possibly completely through the substrate.

The present invention can be further understood with reference to the following description in conjunction with the appended drawings, wherein like elements are provided with the same reference numerals. In the drawings:

Figure 1 is a cross-sectional view of a portion of a conventional inkjet printhead;

Figure 2 is a pictorial view of a printhead according to one embodiment of the present invention;

Figures 3 and 4 show the printhead of Figure 2 being folded;

Figure 5 is a pictorial view of a printhead according to a second embodiment of the invention;

Figure 6 is a pictorial view a printhead according to a third embodiment of the invention;

Figure 7 is a side sectional view of the printhead of Figure 6;

Figures 8 and 9 show the printhead of Figures 6 and 7 being folded; and

Figures 10-12 show a variation of the third embodiment and how it is folded to form a monolithic assembly.

As shown in Figure 2, a printhead of a thermal inkjet printer includes a flexible substrate 10 having at least one fold means 11 that allows a first section 12 of the substrate 10 to be folded over a second section 13. The fold means 11 can comprise spaced-apart perforations that extend completely through the substrate (Figure 2) or, alternatively, spaced-apart slot-like depressions or apertures that extend only part-way through the substrate. The perforations or depressions can have circular, diamond, hexagonal or other shapes that promote hinge formation along a predetermined straight line. For example, the perforations can comprise 100μm diameter apertures with their centers spaced about 150μm apart. As another example, the perforations can have elongated hexagonal shapes that have a length of 200μm and an aspect ratio of about 3:1 with centers about 250μm apart. In the preceding example, when the apertures are formed in a flexible substrate consisting of the polyimide material known as "UPILEX" in thicknesses ranging from 2 to 5 mils, as the fold is made, one surface of the substrate fractures while the other remains unbroken and forms a hinge that connects the sections together. This effect is not requisite for the hinge means to be successful and may not occur with other materials and fold means.

With the fold means 11 formed as described above, the two substrate sections can be folded to overlie each other as shown in Figures 3 and 4. The resulting structure can be said to be monolithic because both the substrate and the orifice plate are formed of the same material.

Preferably, the substrate 10 comprises a polymer material ranging in thickness from about 1 to 5 mils. The polymer can comprise a plastic such as polyimide, teflon, polyamide, polymethylmethacrylate, polyethyleneterephthalate (PET) or mixtures thereof. For such substrates, the told means 11 preferably is fabricated by laser ablation, using an excimer laser.

As also shown in Figure 2, at least one inkdrop ejection chamber 14 is formed on the surface of the substrate section 13, and at least one ink inlet aperture 17 is formed through the substrate section 12. It should be noted that the ink inlet aperture 17 is positioned to be in fluid communication with the inkdrop ejection chamber 14 when the two sections 12, 13 are folded over each other as shown in Figures 3 and 4.

As further shown in Figure 2, at least one ink outlet orifice 18 is formed through second substrate section 13, i.e., on the side of the fold means 11 opposite the laser ablated ink inlet apertures 17. Again. as shown in Figure 3 and 4, the ink outlet orifice 18 is located to be in fluid flow communication with the ink-drop ejection chamber 14 when the first and second sections are folded over each other.

When photo-ablating the told means 11, the ink inlet apertures 17, the ink outlet apertures 18, and the perforations for the fold means 11 can be formed at the same time. In practice, this is done by using a suitable mask and a single food exposure to laser energy. Normally, thin film resistors 22 are formed on substrate 10 prior to forming the apertures; thus, when the mask has been aligned relative to the resistors, all of the apertures formed by the exposure through the mask will be in proper alignment.

Finally as shown in Figure 2, thin film conductor lines 21, a thin film common conductor line 23 and a barrier means 24 are formed on substrate 10. Preferably, the resistors 22 and the outlet apertures 18 are located such that the told means 11 is spaced substantially from the thin film areas. Also it is preferred that the barrier means 24 is fabricated as a dry film barrier; alternatively, however, the barrier means can comprise a photo-ablated region on the substrate 10. In either case, the inkdrop ejection chamber 14 is defined by the barrier means 24.

It should be understood that the above-described folded assembly can be connected to an inkjet pen body either with the resistors 22 facing towards or away from the pen body. When assembled with the resistors facing the pen body, the ink inlets can be used as ink outlets and the ink outlets can be used as ink inlets. In other words, depending on the orientation of the tolded assembly, the orifices 17 and 18 can be used interchangeably as ink inlets or ink outlets.

In an alternative embodiment shown in Figure 5, the substrate 10 includes a first section 12 including resistors 22 and a second section 13 including outlet apertures 18. The substrate 10 is foldable along the fold means 11 such that the outlet apertures 18 register with the resistors 22. In this embodiment, a single ink inlet aperture 26 supplies ink to more than one inkdrop ejection chamber. The barrier means is utilized to define the ink ejection chamber as before and also to define a common ink manifold area. The conductor lines 21 and common conductor 23 complete the electrical means for heating the resistors 22.

In the general case, more than two fold means can be used to form additional sections which can be tolded over each other. For example, in the embodiment shown in Figures 6 and 7, the flexible substrate 10 includes a second fold means 19 that defines a third section 20 of the substrate 10. More particularly, in this embodiment, the first told means 11 separates sections 13 and 20 of the substrate 10, and the second fold means 19 separates the sections 20 and 12. The first section 12 includes ink inlets 17 and resistors

22, the second section 13 includes ink outlets 18, and the third section 20 includes inkdrop ejection chambers 14.

The structure in Figures 6 and 7 can be folded in various ways to form a monolithic inkjet printhead. For instance, as shown in Figures 8 and 9, the section 13 can be folded to overlay the third section 20 with the third section 20 being between the first and second sections 12, 13. It may be noted that, prior to folding, the third section 20 is between the first and second sections 12, 13.

In the embodiment in Figure 10, the second section 13 is located between the third and first sections 20, 12 prior to folding the substrate 10. In the folded assembly, as shown in Figures 11 and 12, the substrate 10 is folded such that the third section 20 fits between the first and second sections 12, 13.

Although the foregoing has described the principal preferred embodiments and modes of operation of the present invention, the invention should not be construed as being limited to the particular embodiments discussed. For example, the fold means 11 can be formed by electroforming techniques applied to metals rather than laser ablation of plastic materials. As another example, the above-described methods can be employed for fabricating various devices, other than inkjet printheads, where it is important the components be carefully aligned in relationship to each other and where it would be beneficial to form the components on a single substrate.

Thus, with the foregoing example and others in mind, it should be understood that the above-described embodiments should be regarded as illustrative rather than restrictive, and it should be appreciated that variations may be made in those embodiments by workers skilled in the art without departing from the scope of the present invention as defined by the following claims.

Claims

1. A printhead of an inkjet printer comprising:
   a flexible substrate (10) having at least one fold (11) therein such that a first section (12) of the substrate (10) can be folded to overlay a second section (13) of the substrate (10), the substrate (10) comprising a polymer material and the fold (11) comprising a photo-ablated portion of the substrate (10).

2. The printhead of claim 1, further comprising:
   a plurality of inkdrop ejection chambers (14) that axe disposed between opposed surfaces of the first and second sections (12, 13) of the substrate (10);
   a plurality of ink inlet orifices (17) in the first section (12) of the substrate (10) with the ink inlet orifices (17) in fluid communication with the Inkdrop ejection chambers (14);
   a plurality of ink outlet apertures (18) in the second section (13) of the substrate (10) with each of the ink outlet apertures (18) in fluid communication with a respective one of the inkdrop ejection chambers (14);
   ink supply means (25) in direct fluid communication with each of the ink inlet orifices (17); and
   the flexible substrate (10) including at least two folds (11, 19) therein with a third section (20) of the substrate (10) overlying at least one of the first and second sections (12, 13).

3. A printhead for an inkjet printer comprising:
   a substrate (10) extending in a longitudinal direction;
   at least one inkdrop ejection chamber (14) on a first section (12) of the substrate (10), the inkdrop ejection chamber (14) being located at a first position on the substrate (10);
   at least one orifice (18) in a second section (13) of the substrate (10), the orifice (18) being located at a second position on the substrate (10); and
   fold means (11) for forming a fold in the substrate (10) whereby the substrate (10) can be folded with the first and second sections (12, 13) placed in a precise predetermined relationship to one another.

4. The printhead of claim 3, further comprising:
   at least one resistor (22), the at least one resistor (22) being disposed on the substrate (10) and located in the inkdrop ejection chamber (14) when the substrate (10) is folded;
   second fold means (19) for forming a second fold in the substrate (10) that allows a third section (20) of the substrate to be folded over the first and second sections (12, 13);
   barrier means (24) that defines the inkdrop ejection chamber (14), with the barrier means (24) comprising a dry film barrier and the resistor (22) being disposed in the inkdrop ejection chamber (14) defined by the barrier means (24) after the first and second sections (12, 13) are folded over one another; and
   the orifice (18) comprising an outlet aperture, the substrate (10) further including at least one inlet orifice (17), the second fold means (19) being located between the inlet orifice (17) and the outlet aperture (18).

5. The printhead of claim 3, wherein the inkdrop ejection chamber (14) comprises a photo-ablated region extending at least part way through the substrate (10).

6. The printhead of claim 3 further comprising a bulk ink supply (25) and the substrate (10) further includes a plurality of ink inlet orifices (17) which are in direct fluid communication with the bulk ink supply (25).

7. The printhead of claim 3 wherein the fold means (11) comprises a row of spaced-apart perforations in the substrate (10), a slot extending only part way through the substrate (10), or a selectively weakened portion of the substrate (10) that allows the substrate (10) to be folded such that the first section (12) of the substrate on one side of the weakened portion overlies the second section (13) on an opposite side of the weakened portion.

8. A method of forming an inkjet printhead, comprising the steps of:
(a) providing at least one thin film resistor (22) on a flexible substrate (10);
(b) providing conductor means (21) on the substrate (10) for electrically heating the resistor (22);
(c) forming at least one inkdrop ejection chamber (14) on the substrate (10);
(d) forming at least one orifice (18) in the substrate (10);
(e) forming a weakened portion (11) of the substrate (10); and
(f) folding the substrate (10) at the weakened portion to form a folded monolithic assembly with the resistor (22) located in the inkdrop ejection chamber (14) and the orifice (18) in fluid communication with the inkdrop ejection chamber (14).

9. The method of claim 8, wherein the orifice (18) comprises an ink outlet aperture, the method further comprising a step (g) of forming at least one ink inlet orifice (17) in the substrate (10), the inlet orifice (17) being in fluid communication with the inkdrop ejection chamber (14) when the substrate (10) is folded in step (f), the substrate (10) comprising a polymer material and the steps (d), (e) and (g) of forming the outlet aperture (18), the weakened portion (11) and the inlet orifice (17) being performed simultaneously by photo-ablating the polymer material by exposing the substrate (10) to laser energy passed through a mask, the method further comprising a step (h) of attaching a bulk ink supply (25) to the folded monolithic assembly with the ink inlet orifice (17) in direct fluid communication with the bulk ink supply (25).

10. A method for fabricating a device in which the components are to be precisely aligned in superposed relationship, one above another, and where at least some of the components can be formed on a single substrate, comprising:
(a) providing a flexible substrate (10);
(b) forming at least two components (14, 17, 18, 22) on the substrate (10);
(c) forming a weakened portion (11) of the substrate (10), the substrate (10) comprising a polymer material and the step of forming the weakened portion (11) being performed by photo-ablation.; and
(d) folding the substrate (10) at the weakened portion (11) to form a folded monolithic assembly with at least two of the components (14, 17, 18, 22) aligned in superposed relationship, one above another.

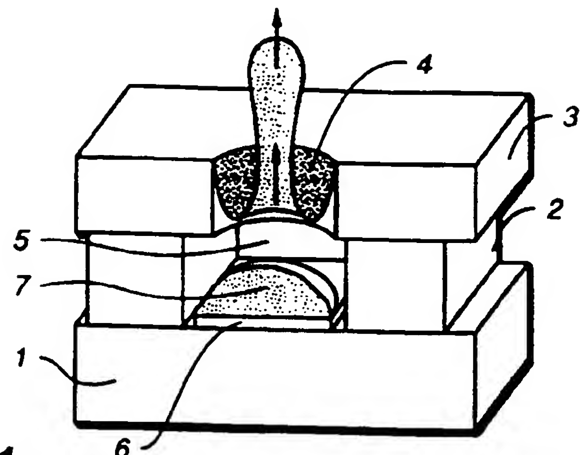

FIG._1
(PRIOR ART)

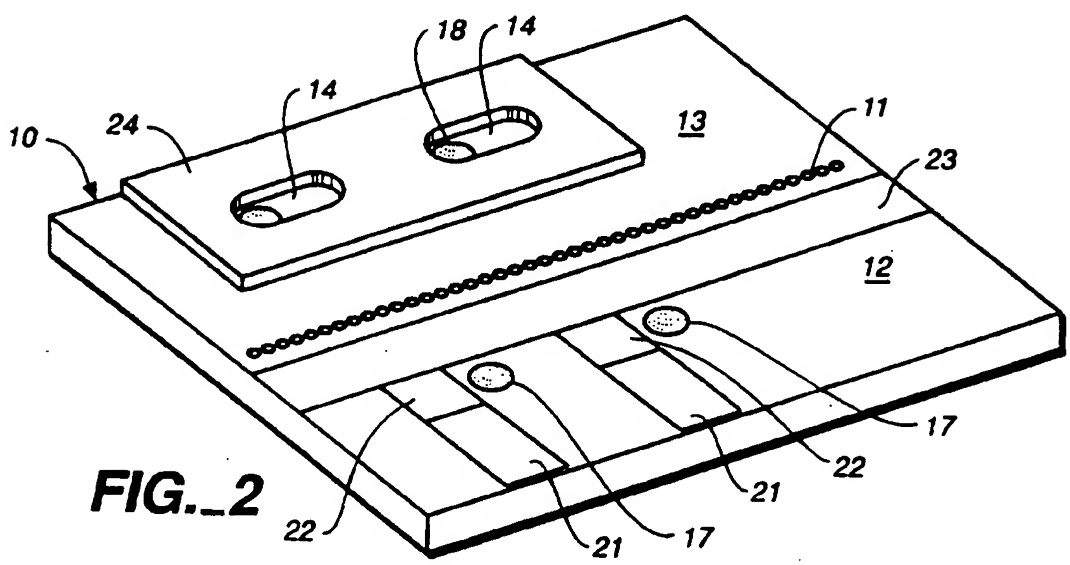

FIG._2

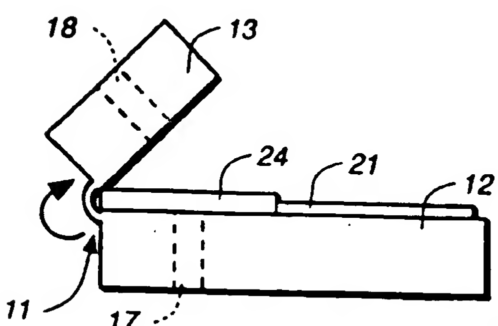

FIG._3

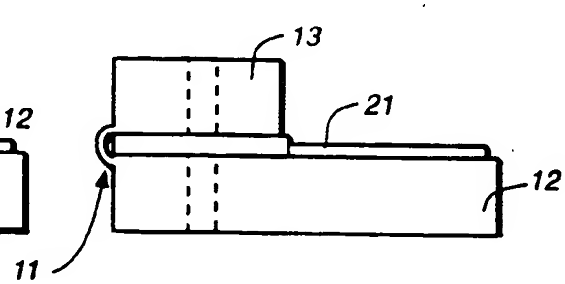

FIG._4

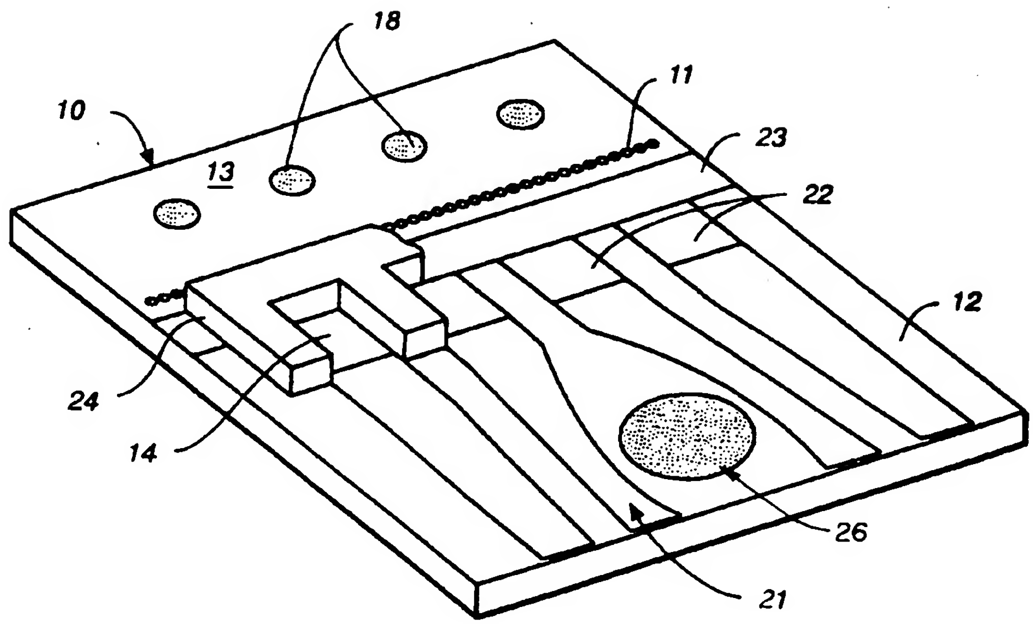

FIG._5

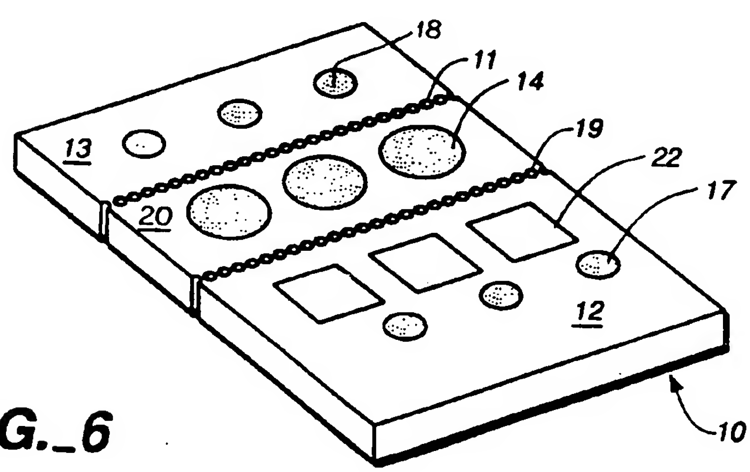

FIG._6

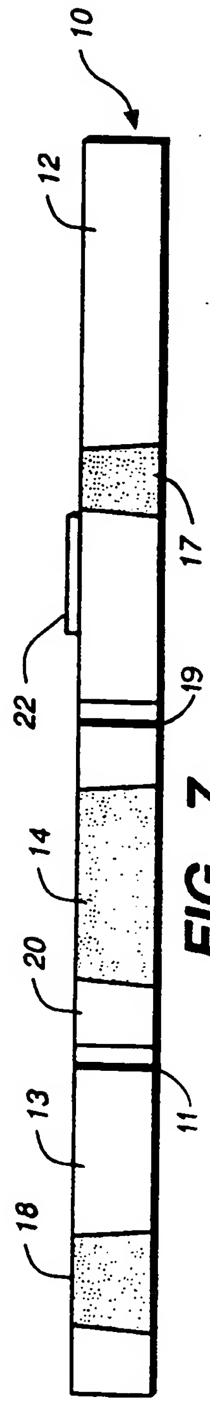

FIG._7

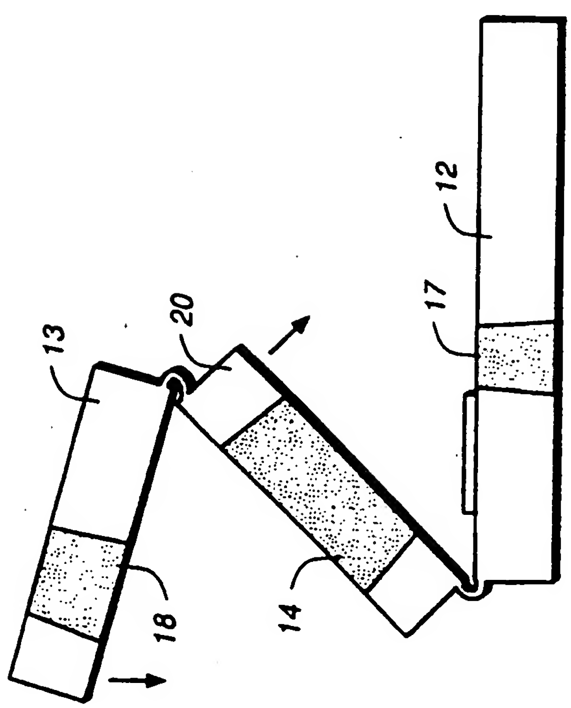

FIG._8

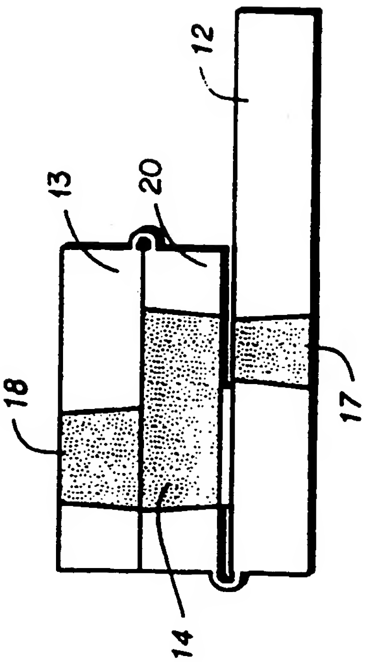

FIG._9

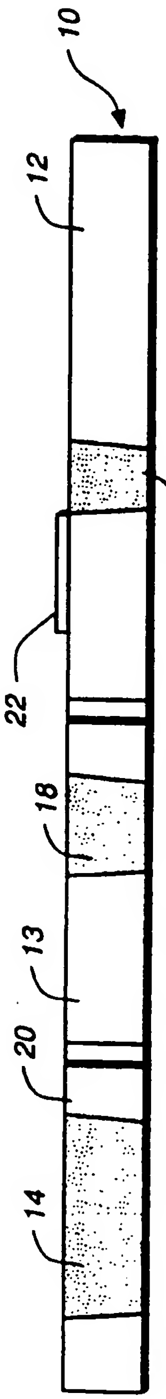

FIG._10

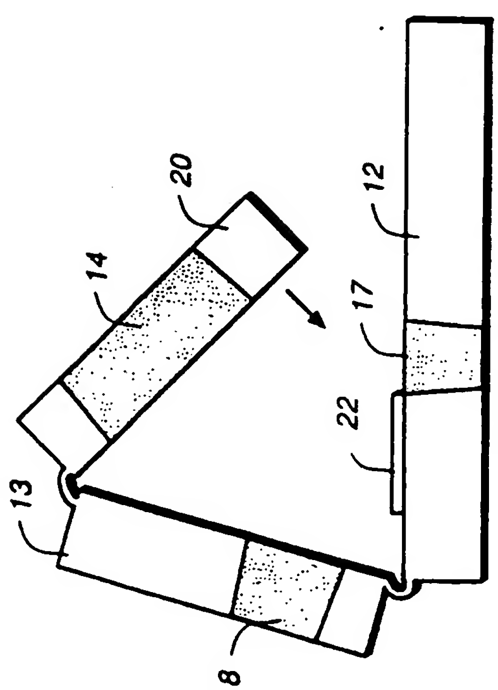

FIG._11

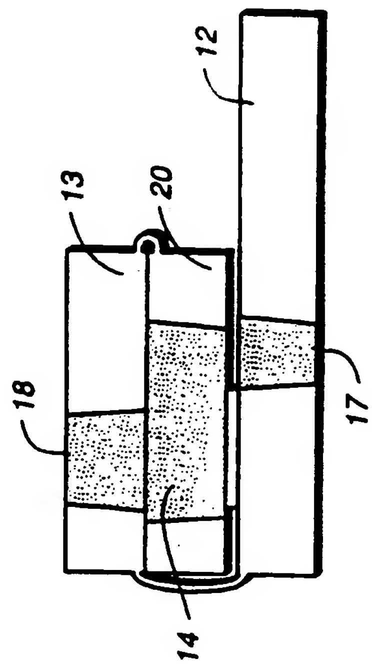

FIG._12

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93302603.1

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP - A - 0 471 157 (HEWLETT-PACKARD) * Totality * --	1,3,5, 8,9	B 41 J 2/16 B 41 J 2/05
A	GB - A - 2 009 049 (PHILIPS) * Totality * --	10	
A	EP - A - 0 352 468 (CANON K.K.) * Fig. 5 * ----	3-6	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			B 41 J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	08-06-1993	WITTMANN

CATEGORY OF CITED DOCUMENTS

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